IMPACTS OF SPACE USE BY HUMANS ON THE LARGE MAMMAL SPECIES DIVERSITY IN THE KWAKUCHINJA-MBUGWE WILDLIFE CORRIDOR, NORTHERN TANZANIA

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ABSTRACT

Assessment of the impacts of settlements and agriculture on species diversity of large mammals was carried out in the Kwakuchinja-Mbugwe Wildlife corridor, northern Tanzania, from early June to mid July 1998 by foot sampling along transects. The corridor connects Lake Manyara and Tarangire National Parks and is vital for the migratory and resident species of large wild mammals as well as for pastoralists. Species richness of large mammals was found to have decreased by 72% while the number of historical migratory routes had declined from five to three. On the other hand, agriculture and settlements grew by 130.4% and 23.5% respectively since 1989. The study further found that there was local extinction of eight species of large mammals specifically eland, *Tragelaphus oryx* (Pallas); Coke's hartebeest, *Alcelaphus buselaphus* (Gunther); buffalo, *Syncerus caffer* (Sparrrman); oryx, *Oryx gazella* (Linnaeus); lesser kudu, *Tragelaphus imberbis* (Blyth); cheetah *Acinonyx jubatus* (Schreber); and leopard, *Panthera, pardus* (Linnaeus). A negative relationship between density of settlements and large mammals ($p < 0.05$) was observed suggesting that settlements hamper the movement of migratory species in the corridor. The study recommended execution of Management Zone Plan (MZP) and later a General Management Plan (GMP) to enable allocation of land uses to appropriate land units. The plans are vital given that the current status of the area has minimum limitation to human use of natural recourses of the area. Establishment of Wildlife Management Areas (WMAs) and Biodiversity Conservation Projects (BCPs) such as Api-Agro-forestry among land uses in villages within the corridor and those adjacent to Lake Manyara and Tarangire National Parks are emphasized.

Key words: Lake Manyara - Tanrangire – Kwkuchinja wildlife corridor corridor

INTRODUCTION

The global human population has increased from two billion to five billion within recent years and another five billion are to be added within the near future (IUCN, 1989). Such increase is said to go hand in hand with exploitation of resources at a rate higher than has been before.

For example, the 1948 census showed that East Africa countries had about 17 million people, a figure said to be about 3 million more than the previous estimate (Worthington, 1952). From this trend, Worthington assumed that the human population for Africa as a whole would have doubled in about fifty years and that the factors operating against fauna and flora will have increased immeasurably in all parts of the continent outside national parks and game reserves.

Like many other countries in the developing world, the Tanzania population is expanding by 3 % per year especially in areas with high agricultural potential which are mainly highlands, lake and river basins, and other areas that receive sufficient and reliable rainfall, have fertile soils and are free of tsetse flies (Gamassa, 1995). He viewed overpopulation in such areas as the prime factor of human mass flow from the areas into "marginal areas", where wildlife management and pastoralism are the prominent traditional land uses (Heady, 1972).

The Kwakuchinja-Mbugwe wildlife corridor being a semi-arid area (Prat & Gwynne, 1977) is among many wildlife areas whose biodiversity are threatened by growing human settlements and agricultural development (Hassan, 1998; 2000). Moreover, it is a subset of the area designated as Game Open Area, a conservation category, which does not restrict settlement or cultivation (Gamassa, 1989). As a result, cultivated land in the area has increased from less than 100 ha (in 1958) to 2,738 ha (in 1989) making agriculture a prominent land use while the human population in the Minjingu and Vilima vitatu villages has increased six fold from 1947 to 1988, indicating an annual growth rate of 6.2 % (Gamassa 1996; 1995; 1989).
Because Boshe (1989) suspected that such rapid population growth coupled with agricultural and settlement development could have affected the corridor's previously documented abundance and species richness of large mammals, he expressed a great need for comprehensive researches in the corridor in order to obtain sound scientific data upon which management and conservation programmes can base.

There had been no assessment in the area for a decade on the abundance and species richness of large mammals. Similarly information on the status of cultivated land and settlement, and their impacts on the species diversity of large mammals were lacking. This study sought to provide this information and recommend management interventions that will minimise the impacts of human use of the corridor space and their associated wildlife resources.

MATERIALS AND METHODOLOGY

Study site

The Kwakuchinja-Mbugwe Wildlife Corridor in northern Tanzania lies between longitude 35^0 48' 21" and 35^0 59' 25" E, and latitude 3^0 35' 38" and 3^0 48' 02" S (Hassan, 1998; 2000). Covering approximately 400 $km^{2,}$ the corridor is a Game Open Area connecting Lake Manyara and Tarangire National Parks (TCP, 2000; Kajuni, 2000; Kidehgesho *et al.*, 2000). With reference to Pratt and Gwynne (1977) the area falls under eco-climatic zone v and experiences short rains between November through January and long rains from February to May, with average annual rainfall of 600 mm (Gamassa, 1995).

To date, that is the only wildlife corridor in the Maasai steppe ecological continuum that links the two parks (Lamprey, 1964). It is vital to 25 large mammal species that move to and from Tarangire National Park (Gamassa, 1996; Moe *et al.*, 1989; Alphoce, 2002). Over 20 ethnic groups with different traditional occupations and life style are known to reside in the corridor, with Maasai and Barabaig (pastoralists), and Mbugwe (agro-pastoralists) being indigenous ethnic groups (Gamassa, 1989). As result, conflicting land use types (i.e. settlements, cultivation, livestock grazing and cattle ranching, phosphate mining, holding ground for cattle, and wildlife management and conservation) form another prominent feature of the area (Gamassa, 1995).

Sampling procedure

Assessment of the impacts of settlements and agriculture on species diversity of large mammals was carried out in Kwakuchinja-Mbugwe Wildlife corridor, northern Tanzania, from early June to mid July 1998 by foot sampling along twelve transects of varying length and inter-distance (Western & Grimsdell, 1979) while collecting data on large mammals, settlement and crop fields.

Accessibility, land use type and vegetation cover governed distribution of transects. These transects were arranged and surveyed in an increasing order. In this case one set of transects ran from West-East (279°) while the other ran from East-West (120°). Recording of wildlife, settlements and cultivation, and their respective perpendicular distance was done within a fixed transect width of 400 m on each side of a line transect (Norton-Griffiths, 1978) following the procedure by Rabinowitz (1997) and Sutherland, (1996). Pace counting was done with the aid of a tally counter (Gamassa, 1989) whereas the length of each transect was consequently derived using a conversion factor of 0.968. All surveys started at 0700 hrs and each transect was surveyed once.

Data analysis

Determination of density for wildlife, settlements and land under agriculture were made following Davis and Winstead (1980). Subsequently, $P = AZ^o / 2Y^o X^o$; where P = Population; A = Total study area; Y^o = Mean perpendicular sighting distance; X^o = Total length of all transects in the study area; and Z^o = Total number of animals or settlements or hectares sighted. Parts of cropfields extending outside 400 m (on each side of the line transect) were not included in the computation of crofield coverage. The total transect length (X^o) was 89.9 km.

RESULTS

Large wild mammals

Seven species of large herbivores were recorded at thirty-nine sighting points. Most of these sites consisted of open grassland, open grassland (seasonally inundated), woodland and bushland. Other animals recorded were black-backed jackal, *Canis mesomelas* Schreber (n =2); a troop of olive baboon, *Papio anubis* Matschie (n = 57); cape hare, *Lepus capensis* Linnaeus (n =1); vervet monkey, *Cercopithecus aethiops* Pocock (n = 4); Kirk's dik-dik, *Rhynchotragus kirkii* Gunther (n=2); ostrich, *Struthio camelus* Linnaeus (n =15) and spotted hyena, *Crocuta crocuta* Erxleben (heard yelling at night). Signs of aardvark, *Orycteropus afer* Pallas (burrows), and bush pigs, *Potamochoerus porcus* Linnaeus (ploughed vegetation) were observed. Old dung of elephant, *Loxodonta africana* Blumenbanch were also observed but excluded from the population estimate since it was not possible to tell their number.

The abundance of large mammals differed between species (Table 1). Proportional abundance showed the following values in decreasing order; impala 37.7 %, zebra 32 %, Thomson's gazelle 18.7 %, Grant's gazelle 8.1 %, giraffe 2.6 %, wildebeest 0.4 % and Bohor reedbuck 0.4%. The mean perpendicular sighting distance ranged between 100m and 400 m. Animals did not tolerate the sight of vehicle or a walker at a distance less than 100m (0.1km).

A comparison of density among species of large mammals showed that impala ranked highest with a density of 5.2 animals / km^2, followed by Burchell's zebra 4.4 animals / km^2, Thomson's gazelle 2.6 animals / km^2, Grant's gazelle 0.9 animals / km^2, giraffe 0.4 animals / km^2, wildebeest 0.1 animals / km^2, and finally Bohor reedbuck 0.1 animals / km^2. Computation of Simpson's index of diversity showed a value of 0.7.

Table 1 Abundance and mean perpendicular distance to large mammals

Species	Estimated population (N)	Mean perpendicular sighting distance (km)
Thomson's gazelle, *Gazella thomsonii* (Gunther)	990.1	0.2
Impala, *Aepyceros melampus* (Lichtenstein)	2001.7	0.1
Grant gazelle, (*Gazella grantii* (Brooke)	430.5	0.2
Burchell's zebra, *Equus burchelli* (Gray)	1700.4	0.2
Wildebeest, *Connochaetes taurinus* (Burchell)	21.5	0.4
Bohor reedbuck, *Redunca arundinum* (Pallas)	21.5	0.1
Giraffe, *Giraffa camelopardalis* (Linnaeus)	139.5	0.2

Settlements

In this study, a cluster of huts under one family or families under the roof of one elder was regarded as one settlement. This was necessary due to the social - life style (polygamism) of many ethinic groups in the area, particularly the pastoralists and agro-pastoralists. Therefore, a total of 1582 settlements were estimated (n=147). From the 1988 work, there was an increase by 23.5 % (from 1281- 1582 settlements) representing an annual increase at 2.4 %. In addition, five fishing villages namely Mfurang'ombe, Malamboi, Mgorore, Minjingu and Oldukai, and three tourist campsites namely Laizer, Saimon Kamakia Elephant and Kigongoni campsites were recorded. Three of the fishing villages emerged in 1997.

Agriculture

Mixed cropping is the most common and nine (9) crop types (Table 2) were recorded. These are cotton, sesame, sunflower and tomato as cash crops; and maize and beans as both cash and food crops. Other crops included several varieties of peas, sorghum, and pumpkins. Sesame and sunflower were introduced within the last decade of the 20th century. The total land under cultivation was 6308.4 ha, representing 16.3 % of the study area. That was equivalent to an increase of 3570.4 ha (from 2738 - 6308.4 ha) representing 130.4 % increase, which in turn implies 13 % annual increase. Of the nine crops, maize took the first position, occupying 5615.6 ha. This constituted about 89 % of total cropland. Sorghum, pumpkin and tomatoes however each constituted < 1%.

Table 2 Estimated land coverage by crops

Crop type	**Estimated ha**
Cotton	329.3 (5.2 %)
Maize & Sesame	78.5 (1.2 %)
Maize	5615.6 (89 %)
Maize and beans	181.5 (2.9 %)
Maize and peas	44.8 (0.7 %)
Beans and sunflower	57.3 (0.9 %)
Sorghum	0.6 (< 1 %)
Pumpkin & sorghum	0.4 (< 1 %)
Tomatoes	0.4 (< 1 %)

Migratory passages, and interrelationship between animals, settlements and agriculture

Five historical migratory routes were identified. Of these, only three persisted to the time of this study (Agustino Mwageni, pers. Comm).

Pearson's coefficient correlation test indicated a negative relationship between density of large mammals and settlements (Table 3 and Figure 1). However, agriculture appeared to have no significant effect on large mammal populations (Table 3 and Figure 2). Similarly, settlements did not show any significant influence on the cropfields pattern (Table 3 and Figure 3).

Table 3 Pearson's coefficient correlation test for the three variables

Variables	Correlation coefficient value	P (Ho)
Large mammals and settlements	r = - 0.530	0.025<P<0.05
Large mammals and agriculture	r = - 0.35	P > 0.05
Settlements and Agriculture	r = 0.379	P > 0.05

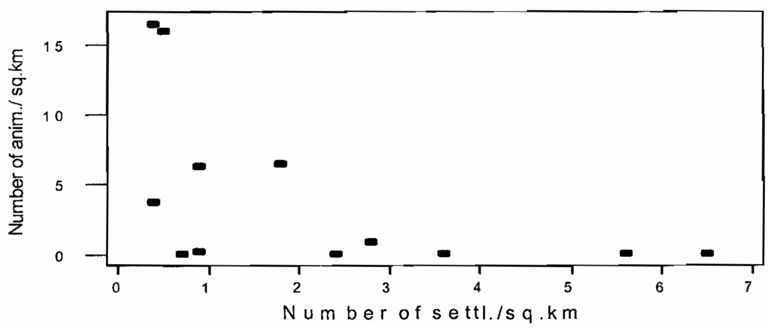

Figure1 Relationships between densities of large mammals and settlements

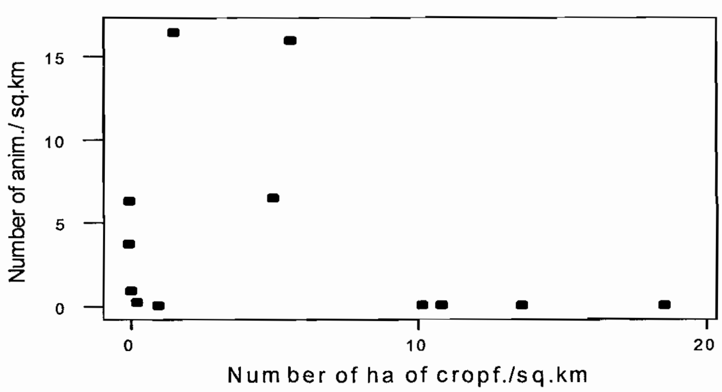

Figure 2 Relationships between densities of large mammals and crop fields

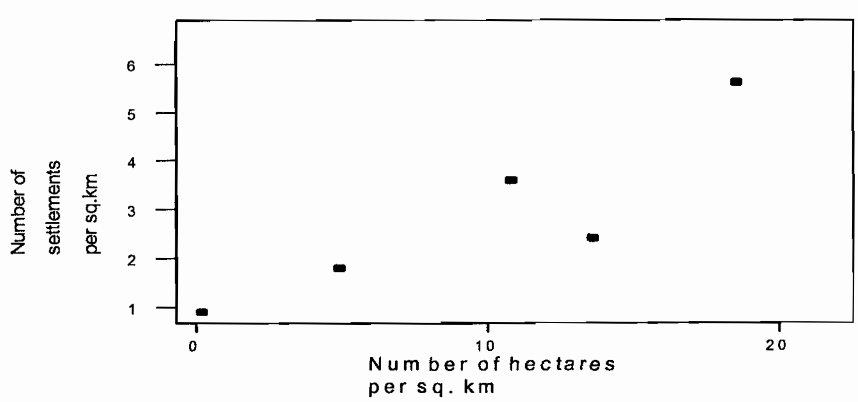

Figure 3 Relationships between densities of settlements and crop fields

DISCUSSION

Species diversity of large mammals

Taking diversity as the number of species counted (Krebs, 1985), the species diversity observed (7 species) was below by 72 % compared to the value reported by Gamassa (1989) who counted 25 large mammal species (in November 1988) in the same area. Comparing to its immediate neighbouring area, Lake Burungi Game Controlled Area, where 15 species of large herbivore were recorded in August to October census (Moe *et al.*, 1989), the diversity observed during this study was below two fold.

Most important are cape eland, *Tragelaphus oryx* (Pallas); Coke's hartebeest, *Alcelaphus buselaphus* (Gunther); buffalo, *Syncerus caffer* (Sparrrman); oryx, *Oryx gazella* (Linnaeus); lesser kudu, *Tragelaphus imberbis* (Blyth); cheetah *Acinonyx jubatus* (Schreber); and leopard, *Panthera, pardus* (Linnaeus), which were reported by both Boshe (1989) and Gamassa (1996) among regular users of the corridor, but none of them were sighted during this study, or had been recently recorded (Agustino Mwageni, pers.comm.). Moreover, Kideghesho (2001) ascertained local extinction of nine species of large mammals in the neighbouring Lake Manyara National Park, Table 4. This shared experience validates the possibility that the 8 species no longer sighted in the corridor may have had been expelled by the settlement and /or agricultural development.

Table 4 Locally extinct large mammal species in Lake Manyara Natinal Park Species

Mammal Species	Year of extinction
Lesser kudu, *Tragelaphus imberbis* Blyth	1957
African wild dog, *Lycaon pictus* Temminck	1960
Cheetah, *Acinonyx jubatus* Schreber	1980
Coke's Hartebeest, *Alcelaphus buselaphus* Gunther	1982
Mountain reedbuck, *Redunca fulvorufula* Afzelius	1982
Cape eland, *Taurotragus oryx* Pallas	1983
Oribi, *Ourebia ourebi* Zimmerman	1983
Black rhinocerous, *Diceros bicornis* Linnaeus	1985
Common reedbuck, *Redunca arundinum* Boddaert	1991

Source: Silkiluwas (1998) quoted in Kideghesho (2001).

According to Gamassa (1989) and Boshe (1989) the migratory herbivores, particularly zebra and wildebeest, start moving into the study area on the way to Tarangire National Park, from mid June and the peak is in July / August (dry season). The animals re-use the corridor on their way back from Tarangire National Park at the on set of rains (early November) and the highest wildlife density is experiences by the end of December. Basing on this calendar, the June /July 1997 and the November 1988 studies were carried out during the time migratory large wild mammals were expected to be in the corridor. This therefore ruled out the influence of seasonality as one possible cause of the above discrepancy. Nevertheless, extra wetness due to *Elnino* weather phenomenon (1334.5mm as opposed to the normal 600mm) experienced during the 1997 / 1998 wet season may have had contributed.

Settlements expansion

Serengeti Ecological Monitoring Programme or SEMP (1987) had estimated 1126 settlements in the area. Gamassa (1989) estimated 1281 settlements in the same area, representing an annul settlement growth of 13.76 %. This study came up with 1582 settlements. Comparing with the 1988 survey, there was an increase by 23.5 % representing an annual settlement growth rate of 2.4 %. As Boshe (1989) and Gamassa (1989) observed, settlements tend to cluster along or near the Great North Road.

Agricultural development

Again, SEMP (1987) estimated a total of 1980 hectares of land under cultivation. This represented 8.25 % of the total study area. Maize was the main crop constituting 1391 hectares (70.25 %). The 1989 results by Gamassa showes that 2738 hectares of land were under agriculture, and that represented 11.41 % of the total area. In this study, 6308.4 hectares were estimated to be under cultivation. This value is equivalent to 16.3 % of the study area. From the 1989 figure, there was an increase of 3570.4 hectares equivalent to 130.4%. This puts an annual increase of cultivated land at a rate of 13 %. Cotton had increased from 2.4 % (Gamassa 1989) to 5.2 % (329.3 hectares) signalling its increasing importance as a cash crop. Maize and beans maintained the dual use.

Apart from cotton, which in 1989 was mentioned by Gamassa as the only cash crop grown solely for market, sesame and sunflower had emerged. On the other hand tomato farming was expanding from for household consumption to commercial scale following introduction of commercial varieties. In his experience, Magadza (1986) sees agriculture and settlement developments to affect animals negatively by increasing the insularization hence reduce species diversity. In other words, settlement and agricultural expansions in wildlife areas cause active displacement of wildlife. Newmark (1996) noted that many Tanzania parks were rapidly becoming habitat islands as a result of expansion of human settlements and agriculture. In turn Hunter (1996) retaliated the call made by Mwalyos to protect the Kwakuchnja-Mbugwe wildlife corridor.

Impacts of settlement and agricultural developments on wildlife

The relationship between large wild mammas and settlement densities revealed that expansion of the latter causes decline of the former. The influence of agriculture over large wildlife mammals could not be depicted clearly, most probable because of small sample size. Importantly, Gamassa (1989) established that agricultural activities have influence on wildlife because their increase leads to the decline of wildlife populations. The relationship between settlement and agriculture was not significant either perhaps for the same reason above.

Lamprey (1964) had identified eight wildlife corridors originating from Tarangire National Park, two of which linked with Lake Manyara National Park. Borner (1985) ascertained that only five were remaining, and that only Kwakuchinja linked with Lake Manyara National Park. It is unequivocal that blockade of the two former historical routes denies animals the right of way.

Apparently, one of the value of wildlife corridors in land use planning for conservation strategies seeks to ensure maintenance of genetic variation through provision of an opportunity to populations in different geographical localities to breed, and guaranteed natural dispersal of organisms including colonisation and re-colonization (Andrews, 1993; Simberloff & Cox, 1987) or movement in response to unfavourable conditions in one part of ecosystem or habitat (Nicholls & Margules, 1991). The unfavourable conditions may include human impact such as poaching. Moreover, corridors increase the overall extent of habitat by linking areas, enabling species with large range requirements to be accommodated, and takes care of species with complex requirements by allowing them to move between separate areas which may meet their needs at different stages in their life cycles or at different seasons (Andrews, 1993). This is vital as the Kwakuchinja-Mbugwe wildlife corridor is a habitat in its own right since it supports resident populations (Hassan, 1998).

Movements of animals guarantee heterogeneity of genetic material consequently preventing inbreeding depression. This in turn lowers the extinction rate in view of equilibrium theory of island biogeography (Diamond & May 1976) and minimises the room for demographic stochasticity (Simberloff *et al.*, 1992; Merriam, 1991) hence maintains biological diversity (Harris & Scheck, 1991). There is no doubt that if Tarangire and Lake Manyara National parks will be separated over sufficient time by human interruptions including unchecked settlement and agricultural development, the two parks will succumb to extinction from endogenous forces such as inbreeding depression or demographic stochasticity. So far Newmark (1996) reported that the rate of extinction of mammals in some Tanzanian parks over the last 35-83 years was significant. He linked the extinction rate with the rampart insularization of the parks since the extinction rate was inversely related to park area.

CONCLUSIONS AND RECOMMENDATIONS

Drop in species diversity coupled with absence of sighting records for other species is indicative of loss of value of this land to animals, particularly large wild mammals. Management intervention is required to meet the conservation and management of biological diversity strategy spelled out in the Wildlife Policy of Tanzania (MNRT, 1998). This will include Management Zone and General Management Plans. There is also a great need to establish biodiversity conservation projects including Api-agroforestry projects in villages occurring within the corridor boundaries and those boldering the Tarangire and Lake Manyara National Parks. This should be achieved through participation of rural communities in question. The project should in particular focus on ways that will ensure meeting ecological requirements for wildlife in the area while at the same time addressing human needs. The overall goal of the project should be to preserve species diversity through *in-situ* procedures.

Land use planning is indispensable for biodiversity conservation. The planning will enable allocation of land use types such as Wildlife Management Area (WMA), settlements, agriculture, livestock grazing, mining etc. to appropriate land units. One expected out put of this exercise is to leave the migratory routes free of anthropological activities. This will consequently enhance animal movements between the two parks, thus increasing both species and genetic diversity. Formulation of general management plan is important as it provides for strategies for solving problems and achieving identified management objectives.

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